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LIQUID CONTROL STRUCTURE

Cross-Reference to Related Application

This application claims the benefit of U.S. Provisional Application No. 60/491,396, filed July 31, 2003.

Field of the Invention

The present invention relates to a liquid control structure for controlling liquid flow from an external body of liquid. The invention also concerns a liquid control structure that is utilized as a separator of liquids and/or solids from a base liquid.

Background

Liquid control structures are used in environmental settings to control the level and/or direction of a flow of an external body of liquid for purposes such as irrigation, drainage, water level control in wetlands, and water quality control. Such structures typically utilize a riser having an inlet and an outlet. Water collects in the riser. When the water reaches a certain height within the riser, it is allowed to exit the riser through the outlet. Prior devices, for example, use dams in the form of weir segments positioned inside the riser. The weir segments are horizontally positioned between the inlet and outlet. Once water reaches the top of the weir segments, it is allowed to flow over the segments to exit the riser. The height of the outlet or weir segments is utilized to establish a water table height within the associated field, or body of water.

Liquid control structures are also utilized to separate solids and liquids from water. Environmental Executive Order 13148, defined as "Greening the Government Through Leadership in Environmental Management," addresses the United States government's need for environmental devices that may be utilized as separators. It is desirable to separate solid debris from the liquid flow, including such substances as silt, rocks, and sticks. It is also desirable to separate liquids from other liquids. For example, flow control structures may be utilized to separate oil from water.

Summary

In a first embodiment of the invention, a device for the selective control of a liquid flow from an external body of liquid or liquid and/or solid separation includes a container, a float, and a valve. The container has an inlet for the intake of a liquid into the container from an external body of liquid, an outlet for the discharge of the liquid from the container, and a closed bottom surface. The float is buoyantly positioned within the container and configured to rise and fall in response to the level of liquid within the container. The valve is positioned inside the container in association with the outlet. The valve is coupled to the float such that the valve opens when the float rises above a preselected height within the container and the valve closes when the float falls to the preselected height within the container. The distance between the float and the valve when the float is positioned at the preselected height determines a height of liquid required to open the valve.

In another embodiment, a flow control device comprises a riser, a float and a valve. The riser has an inlet for the intake of a fluid, an outlet for the exit of a fluid, and a closed bottom surface. The float is positioned inside the riser and configured to travel in response to a fluid level in the riser. The valve is positioned inside the riser and is coupled to the float. The valve is movably response to the travel of the float and is coupled to the outlet. The valve is oriented at an angle relative to horizontal.

In another embodiment, a method for controlling liquid flow from an external body of liquid includes providing a container having an inlet and an outlet within the container, disposing a valve between the inlet and the outlet, and coupling a float to the valve. The float is buoyantly responsive to liquid that enters the container such that the valve opens when the float rises above a preselected height within the container and the valve closes when the float sinks to the preselected height within the container. The distance between the float and the valve when the float is positioned at the preselected height determines a height of liquid required to open the valve. A method for separating liquids and/or solids from a base liquid is also provided.

Brief Description of the Drawing Figures

Fig. 1 is a perspective cross-sectional view of a first embodiment of a liquid control structure according to the invention;

Fig. 2 is a cross-sectional view of the structure of Fig. 1 taken at a position that is rotated 90° relative to the view shown in Fig. 1;

Fig. 3 is a cross-sectional view of the structure of Fig. 1 taken at a position that is rotated 180° relative to the view shown in Fig. 1;

Fig. 4 is a perspective cross-sectional view of a second embodiment of a liquid control structure according to the invention;

Fig. 5 is a cross-sectional view of the structure of Fig. 4 taken at a position that is rotated 90° relative to the view shown in Fig. 4;

Fig. 6 is a cross-sectional view of the structure of Fig. 4;

Fig. 7 is a perspective cross-sectional view of another embodiment of a liquid control structure according to the invention;

Fig. 8 is a cross-sectional view of the structure of Fig. 7;

Fig. 9 is a cross-sectional view of the structure of Fig. 1 in operation showing the valve in a closed position;

Fig. 10 is a cross-sectional view similar to that of Fig. 9, but with the valve in an open position; and

Fig. 11 is another embodiment of the flow control structure according to the invention shown with the valve in an open position, with solid debris floating on the surface of the liquid inside the structure and solid debris resting on the bottom of the structure.

Detailed Description

Referring to Figs. 1-8, the flow control structure 10 of the invention includes a container 12, an inlet 14, an outlet 16, a float 18, and a valve 20 positioned inside the container 12. The valve 20 is positioned adjacent the outlet 16 to control flow from the container 12. The flow control structure 10 may be used to control the level of liquid and/or the direction of flow of a liquid for irrigation, drainage, wetlands, leach fields, septic systems, or water quality purposes. The flow control structure 10 may also be used to separate oil, gases, and suspended solids from a base liquid, slurries, and sludge. Applications include onsite waste management and highway drainage, among others.

The flow control structure 10 described herein accomplishes the functions of a water control gate, stop valve, valve structure, gate valve, oil/water separator, and other structures

that provide water level control for wetlands, drainage, and irrigation applications. For example, the structure 10 may be used as a water control gate for maintaining the water level of a field or an animal feed lot. This is advantageous, for example, for reducing nitrate release into the ground water. Nitrates are found in such things as animal waste and fertilizers. They serve to fertilize soil and are useful for agricultural purposes. Nitrates are very soluble. As a result, they may easily flow into ground water. Elevated nitrate levels in ground water may pose a risk to human health. Water control gates are used to maintain the water level in the ground instead of allowing water, and the dissolved nitrates, to flow into the water supply.

The term liquid, as used herein, refers to a fluid that may or may not have suspended therein oils, gases, solids, chemicals and nutrients. The term liquid, as used herein, also may include more than one type of liquid, such as liquids having differing densities or compositions that are combined together in a solution. A liquid will typically include a base liquid, such as water. Additions to the base liquid may include silt, oil, debris, or other materials.

The container 12 of the invention, which is also known as a riser 12, is typically buried in the ground. The riser 12 includes a side wall 22, a bottom inner surface 24, a floor support structure 26, and a top opening 28. The top opening 28 of the riser 12 is positioned at ground level GL and the container 12 extends downwardly into the ground such that a longitudinal axis X-X of the container 12 is preferably perpendicular to the ground surface. The shape and or orientation may vary from the structures 10 shown in the drawings, the invention not being limited to the shapes or orientations shown.

The inlet 14 of the riser 12 is connected to an external body of liquid. Depending upon the application, the external body of liquid may be a pond or lake, or underground piping associated with a wetland or field, among other external bodies of liquid. In the embodiments shown in Figs. 1-8, the inlet 14 is in the form of a pipe that is associated with an external body of liquid at one end and the container 12 at the other. The inlet may alternatively be associated with a conduit that has any type of desired cross-section.

The riser 12 serves as a storage container for liquid that enters through the inlet 14. Liquid that enters the riser 12 first falls against the bottom surface 24 of the riser 12 and collects within the riser 12 until it is allowed to exit through the outlet 16.

The outlet 16 of the riser 12 is also a pipe that is positioned inside the container 12 at one end and extends outwardly from the container 12 at the other end. The outlet pipe 16 may extend to a stream or other run off, such as a leaching field. As shown in Figs. 1-6, the outlet pipe 16 includes an elbow 30 at the container end. A preferred elbow 30 has a bend of about 90°. The elbow 30 is positioned inside the riser 12 and the opening of the elbow 30 faces upwardly. In a preferred embodiment, a vortex plate 31 is positioned in the outlet 16 and serves to break up any vortices that are formed in the output flow as liquid enters the outlet 16. The outlet 16 shown in Figs. 7 and 8 is a pipe that extends into the riser 12. It does not utilize an elbow or a vortex plate. While the outlet 16 is depicted as being associated with a round pipe, it may alternatively be associated with a conduit that has any type of desired cross-section.

The inlet 14 and outlet 16 of the riser 12 are preferably positioned at a height that is above the height of the bottom surface 24 of the riser 12. By having the height of the inlet 14 and outlet 16 elevated above the bottom surface 24, solids or liquids having a density that is greater than the density of the base liquid may sink to the bottom surface 24 of the riser 12 and solids or liquids having a density that is less than the density of the base liquid may rise to the top of the base liquid.

The inlet 14 and outlet 16 pipes are shown in the figures as having a different diameter. It is preferred that the outlet 16 have a cross-sectional dimension, such as a diameter, that is larger than that of the inlet 14 in order to allow the riser 12 to drain properly and to close the valve 20 once drained. However, there may be instances where it is desirable to have an inlet 14 and outlet 16 that are the same dimension.

A valve 20 is coupled to the outlet 16 within the riser 12. In a preferred embodiment, the valve 20 is a flapper valve that is hinged at one side and opens at the other. In Figs. 1-6, the flapper valve 20 is positioned over the opening that forms the outlet 16 in the elbow 30. In Figs. 7-8, which do not utilize an elbow, the flapper valve 20 is positioned over the pipe opening 16. The opening is preferably open and free of obstructions such that liquid may freely flow into the outlet 16 once the flapper valve 20 is opened.

In a preferred embodiment, as shown in Figs. 1-8, the flapper valve 20 includes a top plate 32 and a flexible seal 34 that is attached to the top plate 32. The flapper valve 20 is shown installed in a horizontal orientation in Figs. 1-6 and at a 45° angle relative to horizontal

in Figs. 7 and 8. As shown, the flapper valve 20 may be oriented at an angle other than horizontal, such as at an angle of about 0° to 60° relative to the horizontal. In a preferred embodiment, the flapper valve 20 is oriented at an angle of 35° to 55° relative to the horizontal. All of these orientations are referred to herein as recumbent.

The valve 20 is coupled to a float 18 that is positioned above the valve 20. The float 18 has a buoyancy that is the same as that of air and is responsive to liquid level within the riser 12. In a preferred embodiment, the float 18 includes a closed cell inner foam core 36 and a plastic outer liner 38 that is sealed around the inner foam core 36. A preferred type of material for the foam core 36 is polystyrene, although other types of foam or materials may also be used. Other types of floats may also be utilized, the invention not being limited to a particular type of float. For example, the float may be formed of a pipe section that is filled with foam (not shown).

In a preferred embodiment, the float 18 has a sliding fit in relation to the inner wall surface 14 of the container 12. In designing the float 18, it is important to provide a float that has a buoyancy sufficient to raise the flapper valve, taking into account the head pressure applied to the valve 20 by the liquid in the riser 12.

As the liquid level in the riser 12 increases, the vertical position of the float 18 rises within the riser 12. As the liquid level in the riser 12 decreases, the vertical position of the float 18 within the riser 12 falls. The position of the valve 20 is tied to the position of the float 18 via a linkage 40 between the valve 20 and the float 18. The valve 20 opens when the float 18 rises above a preselected height H and the valve 20 closes when the float 18 falls to the preselected height H within the container 12.

The linkage 40 between the float 18 and the valve 20 may be rigid, such as the bar 42 shown in Figs. 1-3. Alternatively, the linkage 40 may be flexible, such as the chain 44 shown in Figs. 4-8. Other types of linkages may also be utilized such as a rope, a cord, or a flexible bar, among other types of linkages. The linkage connects the valve 20 to the float 18 and the length of the linkage 40 is adjustable based upon the liquid level desired within the riser 12 before the valve 20 opens. The length of the linkage 40 between the float 18 and the valve 20 determines a height of the liquid required inside the riser 12 before the valve 20 will open.

A head pressure is applied to the valve 20 as the liquid level rises in the riser 12. The amount of pressure that is applied to the valve 20 may be adjusted by adjusting the float 18

height via the linkage length. The length of the linkage 40 may be adjusted, for example, with the use of a chain latching mechanism 84, an example of which is shown best in Figs. 7 and 8. The chain latching mechanism 84 is positioned on top of the float 18 and includes a first cord 86 that is coupled to a latch 88. The latch 88 includes an engaging part 90 for engaging the chain 44. One end of the first cord 86 extends around a pulley 92 and is connected to the latch 88. The other end of the first cord 86 may be tied off around the winch arm 62. The latch 88 has an engaged position and an unengaged position, which are determined based upon a pulling force applied by the first cord 86 and a spring (not shown) positioned inside the latch 88 which biases the engaging part 90 into engagement with the chain 44. When the first cord 86 is pulled by a user, the engaging part 90 of the latch 88 disengages from the chain 44. When the first cord 86 is released, the latch engaging part 90 is biased by the spring within the latch 88 to engage the chain 44.

The position of the float 18 at height H may be set by pulling on a second cord 94 that is attached to the top of the float 18. The second cord 94 is secured around the winch arm 62 at the top of the riser 12. In order to position the float 18 at a desired height H, the user pulls up on the first cord 86 to disengage the latch 88. The user then pulls on the second cord 94 to move the float 18 to a desired position. When the float 18 is at the desired position, the first cord 86 is released to engage the chain 44. Preferably, during this process, the chain 44 remains taut.

In operation, liquid enters the riser 12 through the inlet 14. As the liquid level in the riser 12 increases, the float 18 rises with the level of liquid. When the float 18 rises above a preselected height H, force applied from the linkage 40 pulls the valve 20 open to release the flow of liquid to the outlet 16. When used as a separator, the materials in the liquid that have a density greater than the density of the base liquid sink to the bottom surface 24 of the riser. These materials may include both solids and liquids. The solids and liquids having a density less than that of the base liquid rise to the top of the base liquid. These materials may also include solids and liquids. In the embodiments shown in Figs. 1-10, the top opening 28 of the container 12 is closed with a cap 46 that is positioned at or near ground level GL. The cap 46 may be removed in order to clean the riser 12 of any sediments that sink to the bottom or debris that floats on the base liquid. In addition, the user may remove liquids, such as oil that float on top of the base liquid, or suction out liquids that sink below the base liquid.

Figs. 1-3 show a first embodiment of the invention where the flapper valve 20 utilizes a mechanical hinge and the linkage 40 between the valve 20 and the float 18 is a rigid bar 42. The valve 20 includes a flexible seal 34 that is attached to a top plate 32, as previously discussed. In a preferred embodiment, the top plate 32 is made of a rigid material, such as stainless steel. Other materials may also be utilized as long as the materials can withstand the force of the liquid in the riser 12 and operate properly. It is preferred, however, that any materials used be corrosion resistant. The top plate 32 may have ribs (not shown) to help support the flexible seal 34, if so desired. A gasket (not shown) may be provided at the outlet 16, if so desired, and the flexible seal 34 may seat against the gasket in a conventional manner to provide extra sealing power when the valve 20 is closed.

In Figs. 1-3, the top plate 32 is attached to a top plate attachment arm 48, which is attached to a valve control lever 50 via a valve control lever pin 52. The valve control lever 50 extends from the valve 20, through the float 18 and to a winch assembly 54 positioned near the top 28 of the riser 12. The valve control lever 50 is utilized to open and close the valve 20 in response to the movement of the float 18.

The valve control lever 50 includes a series of adjustment holes 56, which allow the lever length, and hence the distance between the valve 20 and the float 18, to be adjusted. A locking pin plate 58 is attached to the top surface of the float 18 to connect the valve control lever 50 to the float 18. A locking pin 60 is inserted through both the locking pin plate 58 and the adjustment holes 56 of the valve control lever 50 in order to fix the distance between the valve 20 and the float 18. When the float 18 rises or lowers, the valve control lever 50 rises and lowers with the float 18.

The upper end of the valve control lever 50 is attached to a winch assembly 54 via the adjustment holes 56 in the valve control lever 50. The winch assembly 54 includes a winch arm 62, a winch pin 64, a winch 66, a winch lever 68, and a winch collar 70. The winch pin 64 attaches the winch assembly 54 to the valve control lever 50. The winch arm 62, winch 66, winch pin 64, winch lever 68, and winch collar 70 rotate with the valve control lever 50 as a result of the winch pin 64 being attached to the valve control lever 50.

Operation of the embodiment of Figs. 1-3 is shown in Figs. 9 and 10. Fig. 9 shows the valve 20 in a closed position while Fig. 10 shows the valve 20 in an open position. Liquid L enters the riser 12 through the inlet 14 . As the liquid L enters the riser 12, it initially falls to

the bottom surface 24 or floor of the riser 12 and begins to accumulate. Before the liquid L reaches the level of the float 18, the valve 20 is in a closed position so that the liquid L may not exit the riser 12, as shown in Fig. 8. Once the liquid level reaches the level of the float 18, the buoyancy of the float 18 causes the float 18 to lift the valve control lever 50. As the valve control lever 50 rises, the lever 50 lifts the top plate attachment arm 48, which lifts the top plate 32 and flexible seal 34 to open the valve 20. The valve 20 opens when the float 18 reaches a preselected height H within the riser 12, as shown in Fig. 10.

The winch arm 62, winch 66, winch pin 64, winch lever 68, and winch collar 70 rotate with the valve control lever 50 as the float 18 rises and lowers. The valve 20 opens through levering because of the hinge action created between the top plate 32 and the valve control lever 50. As a result, the amount of force necessary to open the valve 20 is reduced. The winch assembly 54, in combination with the float 18 and locking pin plate 58 provide the levering effect to open the seal 34. As the valve 20 opens, liquid rushes into the outlet 16 and lowers the liquid height within the riser 12, thereby lowering the height of the float 18 to the preselected height H, where it closes the valve 20. When the float 18 is below or at the preselected height H, the valve 20 will remain closed. When the float 18 is above the preselected height H, the valve is open.

A second embodiment of the flow control structure 10 is shown in Figs. 4-6. This embodiment uses a linkage 40 that is flexible and a living hinge 72 instead of a mechanical hinge at the valve 20. In particular, Figs. 4-6 depict a valve 20 having a flexible seal 34 and a top plate 32. In a preferred embodiment, the top plate 32 is rigid and is made of stainless steel, although other embodiments provide for the use of other materials and for a non-rigid top plate. The flexible seal 34 is formed as a sheet of elastomeric material that provides an integral flexible living hinge 72. A rod 74 extends through the elastomeric material of the seal 34 to hold the seal 34 in position and the rod 74 extends upwardly through the float 18 to maintain a lateral position of the float 18 within the riser 12.

The linkage 40, as shown in Figs. 4-6, is a flexible chain 44. The float 18 includes a float holder 76 that is positioned on the upper surface of the float. The chain 44 extends upwardly through the float 18 and the float holder 76. The chain 44 is connected to the float 18 at the float holder 76 via a pin (not shown) such that a length between the valve 20 and the float 18 is established by locking the chain 44 to the float holder 76 at a given height. The top

end of the chain 44 is attached to a winch assembly 54 (not shown in Figs. 4-6) that is similar to that shown and described in connection with Figs. 1-3. Other types of winch assemblies may also be used.

In operation, as liquid enters the riser 12 through the inlet 14, the liquid flows to the bottom surface 24 of the riser 12 and begins to rise while the valve 20 is still closed. As the liquid accumulates, the float 18 begins to rise and lifts the linkage chain 44. When the float 18 hits a preselected height H, the linkage chain 44 becomes taut and lifts the top plate 32 of the valve 20. As the chain 44 lifts the top plate 32, the seal 34 separates from the outlet opening 16 with a hinge action from the living hinge 72. The linkage 40 provides a levering action to open the valve 20, thereby resulting in a reduced force to open the valve 20.

In both of the embodiments shown in Figs. 1-6, the inlet 14 pipe enters the riser 12 at a height that is greater than the height of the outlet pipe 16.

As shown in Figs. 7 and 8, a third embodiment of the flow control structure utilizes inlet and outlet pipes 14, 16 that are positioned at the same height such that the bottom of each pipe lies in the same plane. It is desirable from an installation standpoint to have the inlet and outlet pipes 14, 16 at the same height so that a contractor installing the riser 12 underground only needs to prepare a single grade. The embodiment of Figs. 7 and 8 includes a valve 20 that is positioned at an angle relative to the horizontal. A preferred angle of 45° is shown, although other angles may also be used, as discussed above.

The flapper valve 20 in Figs. 7 and 8 utilizes a mechanical hinge and the linkage 40 between the valve 20 and the float 18 is a flexible chain 44. The valve 20 includes a rigid top plate 32 that has arms 96 at both ends that bend downwardly to trap a flexible seal 34 in position under the plate 32. The seal 34 includes a sheet of rubber that extends over part of the surface of rigid plate 32. The valve also includes two plastic washers 98, which are positioned near the center of the seal 34 and which together sandwich the seal 34. A fastener 100, such as a screw and bolt extends through the washers 98, seal 34, and rigid plate 32 to hold the seal 34 in place. More than one fastener 100 may be used. The washers 98 also serve to create a conical-type surface on the seal 34, which improves the sealing characteristics of the seal 34 by providing a positive sealing surface against the outlet 16.

The top plate 32 is attached to a top plate attachment arm 48, which is attached to a valve control lever 50 via a valve control lever pin 52. One end of the valve control lever 50

is connected to a hinge 102 and the other end of the valve control lever 50 is connected to the chain 44.

The upper end of the chain 44 is attached to the winch assembly 54. The winch assembly 54 is used to open the valve 20 manually by rotating the winch arm 62 in a conventional manner. As the winch arm 62 is rotated, the chain 44 wraps around the winch arm 62 to draw the top plate 32 upwardly and open the valve 20.

Fig. 11 shows an alternative embodiment of the invention in the form of a catch basin 80. The catch basin 80 has an open top that is covered by a grate 82. Liquid enters the catch basin 80 through the open top 28 and the grate 82 is utilized to block large debris from entering the catch basin 80. The catch basin 80 shown utilizes the valve 20 of Figs. 1-3, but, alternatively, may use the valve 20 of Figs. 4-6 or 7-8.

Operation of the catch basin 80 is similar to the prior embodiments, except that the catch basin 80 utilizes the open top end 28 as the inlet 14. Liquid flows into the catch basin 80 through the inlet 14. Once the liquid level, and hence the float 18, within the basin 80 raises past the preselected height H, the valve 20 will open and allow liquid to exit through the outlet 16.

The container 12 may be formed from a class of rigid materials that include, but are not limited to plastic, fiberglass, concrete, or metal. A preferred type of plastic is high density polyethylene (HDPE). In one embodiment, the container 12 is formed from a corrugated pipe having a smooth walled liner, although the container 12 alternatively may be smooth-walled pipe. The inlet 14 and outlet 16 pipes may also be corrugated or smooth-walled pipes, although smooth-walled pipes are shown as preferred in the drawing figures. The inlet 14 and outlet 16 pipes may be welded to the container 12. Alternatively, the entire unit may be formed as a one piece molding through known molding techniques, such as roto molding.

In installing the liquid control structure 10 in the ground, the container 12 may be made of a tubing that can be cut off at a desired length once the unit is installed in the ground. In this way, the same liquid control structure 10 can be used with differing depth projects.

The container 12 may be provided in any desirable dimensions. For example, the riser 12 can be provided in a diameter of 24 or 36 inches. For a 24 inch diameter riser, the inlet diameter can be 8 inches and the outlet diameter 10 inches. For a 36 inch diameter riser, the inlet diameter can be 15 inches and the outlet diameter 18 inches. These dimensions are

provided for illustration purposes only, the invention not being limited to a particular size of tubing.

The flexible seal 34 of the flapper valve 20 may be formed of any type of flexible material. A preferred embodiment utilizes gum rubber. The rigid plate 32, top plate attachment arm 48, valve control lever 50, valve control lever pin 52, hinge 102 and linkage 40 are all preferably made of a corrosion resistant material, such as stainless steel. The winch assembly 54 and float parts 18, 84 may also preferably be made of a corrosion resistant material, such as stainless steel. In a preferred embodiment, the chain 44 is made of nickel cadmium plated steel. Other types of materials may also be utilized without departing from the invention.

The above invention has been discussed as utilizing a float 18 in order to open the valve 20 in response to the liquid level in the riser 12. Alternatively, the float 18 may be replaced with a solar or electric powered motor that utilizes a sensor (not shown) to gauge the height of liquid within the riser 12. Thus, as used herein, the term float 18 is understood to include other devices that serve to open the valve 20 when the liquid in the riser 12 raises past the preselected height H.

While various features of the claimed invention are presented above, it should be understood that the features may be used singly or in any combination thereof. Therefore, the claimed invention is not to be limited to only the specific embodiments depicted herein. In addition, the term substantially, as used herein, is used as an estimation term.

Further, it should be understood that variations and modifications may occur to those skilled in the art to which the claimed invention pertains. The embodiments described herein are exemplary of the claimed invention. The disclosure may enable those skilled in the art to make and use embodiments having alternative elements that likewise correspond to the elements of the invention recited in the claims. The intended scope of the invention may thus include other embodiments that do not differ or that insubstantially differ from the literal language of the claims. The scope of the present invention is accordingly defined as set forth in the appended claims.